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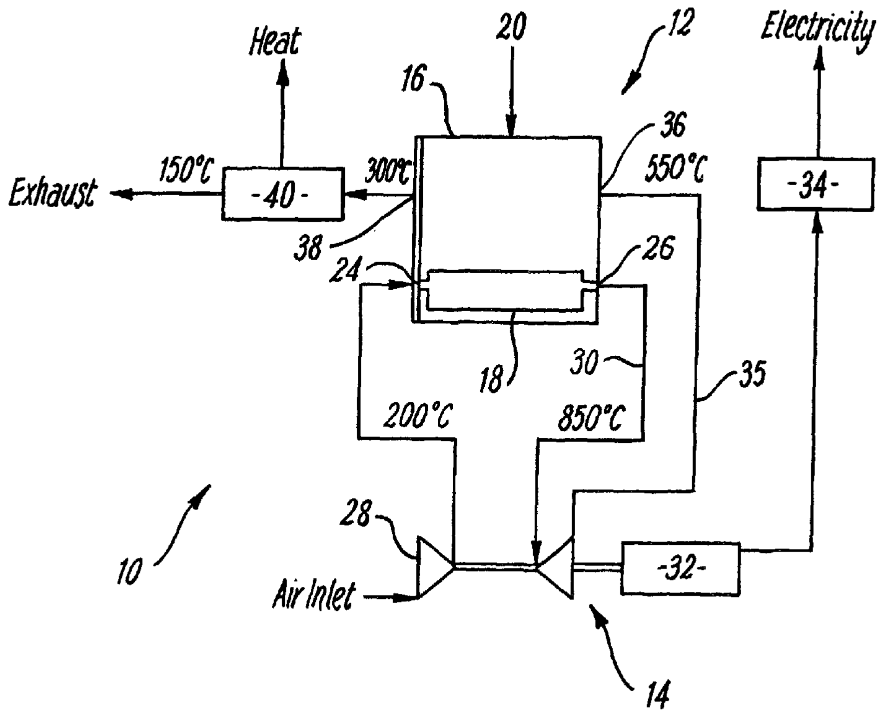
(54) Title: POWER GENERATING SYSTEM



(57) Abstract: A power generating system (10) comprises a combustion arrangement(12) in which combustion of fuel, and in particular sustainable or renewable fluid, is used to indirectly heat fluid, such as air to drive a turbine (14) to generate power. The arrangement (12) includes a combustion chamber (16) at or near the top of which is a heat exchanger (18).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

POWER GENERATING SYSTEM

The present invention relates to power generating systems.

The generation of electrical power and particularly relatively small scale power generation employing conventional techniques has several disadvantages.

Recently, micro turbines, which are small, recuperated gas turbines have been developed that offer many benefits over conventional small scale power generation technologies. Their principal benefits are reduced costs, increased reliability and availability and also ultra-low emissions.

However a significant disadvantage of micro turbines is that they can only be operated from gaseous and liquid fuels.

According to the present invention there is provided a power generating system comprising a combustion arrangement in which combustion of fuel material is used to heat a fluid and a turbine which is driven by the heated fluid to generate power.

The turbine is preferably a gas turbine, and may comprise a micro turbine.

Preferably the combustion arrangement comprises a combustion chamber associated with which is a heat exchanger through which fluid passes to be heated.

The heat exchanger may comprise a fluid inlet through which preferably partially pre-heated fluid is introduced into the heat exchanger. Fluid may be introduced into the heat exchanger under compression, and may have been passed through a compressor which may have pre-heated the fluid for introduction. Fluid may be introduced at a temperature in the range 150-250°C, and preferably 200°C. The fluid is preferably a gas, and may be atmospheric air.

Preferably the heat exchanger is located in an upper part of the combustion chamber and preferably at or near the top thereof. The heat exchanger may comprise a conduit through which fluid flows to be heated, the conduit defining a tortuous path to facilitate the heating of air therein. The heat exchanger preferably keeps the fluid separate from combustion gases generated during combustion, whilst allowing the gases to pass around the outside of the conduit whereby to heat the fluid passing through the conduit.

Means may be provided in the heat exchanger to divert combustion gases over the conduit to facilitate heat transfer. The means may be in the form of baffles which may be selectively removable. Preferably the heat exchanger further comprises insulation materials to further improve heat transfer. The insulation material may line the inside of a housing of the exchanger and may comprise ceramics material.

The heat exchanger may comprise materials able to resist high temperatures and retain strength and geometry at temperatures up to in the order of 1000°C whilst providing good conduction of heat, such as exotic stainless steel or other suitable, conductive yet durable material. The heat exchanger is preferably readily dismantled, at least in part, to facilitate cleaning thereof, in particular cleaning of the outside of the conduit for example to remove combustion by-products such as soot and other carbonaceous deposits.

Preferably the heat exchanger is arranged to allow fluid passing therethrough to be heated to approximately 800-900°C, depending upon the material being combusted.

Preferably the combustion chamber is arranged to accommodate combustion of a range of fuel materials, in particular solid fuels such as combustible waste, fossil fuels and wood. It is preferable to use sustainable or renewable fuels.

Preferably heated fluid exits the heat exchanger to be introduced to the turbine to drive the turbine to generate electrical power. A conduit may connect the heat exchanger to the turbine which may be remote from the heat exchanger. Means may be provided to process generated power, such as an inverter/rectifier means.

Preferably means is provided to feed heated fluid which has driven the turbine back into the combustion chamber where any residual heat in the fluid will facilitate and enhance the efficiency of combustion.

The system may further comprise means to utilise waste gases from the combustion chamber, particularly to use the residual heat in the gases to heat for example an appliance, such as a radiator, before the gases are exhausted from the system.

The invention further provides a method of generating power, the method comprising combusting fuel in a combustion arrangement to heat fluid and using said heated fluid to drive a turbine to generate power.

The method may comprise the use of a system substantially as defined in any of the preceding twelve paragraphs.

The invention further provides a combustion arrangement as described in any of the preceding thirteen paragraphs.

A preferred embodiment of the present invention will now be described by way of example only, with reference to the accompanying drawings in which:-

Fig. 1 is a schematic representation of a power generating system according to the present invention;

Fig. 2 is a plan view of a heat exchanger according to the present invention; and

Fig. 3 is an elevation view of the heat exchanger of Fig. 2.

Referring to the drawings there is provided a power generating system 10 comprising a combustion arrangement 12 in which combustion of fuel material (not shown) is used to heat fluid, such as air and a turbine 14 which is driven by the heated fluid to generate power.

In more detail, the combustion arrangement 12 comprises a combustion chamber 16 at or near the top of which is located a heat exchanger 18. The combustion chamber comprises a fuel inlet 20, generally towards the bottom thereof. The chamber may be constructed of generally conventional materials, and may comprise an outer metallic casing lined with fire resistant material, such as firebrick.

Referring particularly to Figs. 2 and 3, the heat exchanger 18 comprises a conduit 22 having an air inlet 24 and an air outlet 26.

The conduit 22 comprises a plurality of passages 26 which define a matrix within the heat exchanger 18 around the outside of which combustion gases from the chamber 16 can circulate to heat air passing through the conduit 22. The conduit 22 is shown comprising four passages 26 a,b,c and d which extend transversely across the heat exchanger 18 from the inlet 24 to a respective end 27 a,b,c,d at which the passages turn through 90° to extend downward a short distance from toward the top of the exchanger toward the bottom. The passages 26 a,b,c,d extend downward a short distance, then across, back across toward the inlet 22, and then down and across until they define a tortuous path extending to the bottom of the exchanger. Toward the bottom the conduit 22 passes beneath a baffle 29 to open into a further array of four passages 26 e,f,g,h which are similar to the passages 26 a,b,c,d. The passages 26 e,f,g,h wind their way up toward the top of the exchanger in similar fashion as described for passages 26 a,b,c,d.

Generally at the top of the exchanger the passages 26 e,f,g,h pass over a further baffle 31 to open into a final array of passages 26 i,j,k,l which wind down in a similar fashion to the outlet 26. This tortuous matrix of passages provides for efficient transfer of heat from combustion gases as they pass around the passages 26 a-l through the space 33 therebetween. The conduit 22 is made of material able to resist temperatures up to in the order of 1000°C whilst retaining strength and geometry and providing for good heat transfer through a high coefficient of conductivity. The heat exchanger 18 is made of exotic stainless steel, although other suitable materials may be used. The baffles 29,31 are selectively removable to enable cleaning thereof and also of the conduit 22. The baffles 29,31 comprise heat reflective material such as ceramic. Further the housing 35 of the heat exchanger may comprise heat reflective material, such as a lining of ceramics material to help retain heat within the exchanger 18 and thereby to facilitate heat transfer within the exchanger 18.

A compressor 28 is provided which receives from atmosphere air through an air inlet and compresses the air which compressed air is fed into the heat exchanger 18 to the inlet 24. The compressed air is preheated to approximately 200°C, the compression of the air achieving this temperature.

The outlet 26 for the heated air exiting the heat exchanger 18 is connected to the turbine 14, which is a gas turbine, preferably a micro turbine, by a conduit 30. Alternatively the turbine 14 may be directly attached to the outlet 26. The air exiting the heat exchanger 18 is approximately 850°C.

The heated air drives the micro turbine 14 and the generator 32 of the turbine to generate electricity, which electrical output may be subjected to an inverter/rectifier 34 before being outputted for further use.

The heated air used to drive the turbine 14 is collected once used to drive the turbine 14 and re-introduced to the combustion chamber 16 via a conduit 35, whereby to enhance and improve the efficiency of combustion. This air is likely to be of a temperature in the order of 550°C, and is inputted into the combustion chamber 16 through an inlet 36.

An outlet 38 is provided in the combustion chamber 16, to allow combustion gases to be vented from the chamber 16, once those gases have been used to heat air in the exchanger 18. The temperature of the gases vented are in the order of 300°C and these are introduced to an appliance such as a radiator or other heating appliance 40 which could be used, by heat exchange to heat an object or a room. This provides further energy efficiency of the system 10.

The gases are then exhausted from the appliance 40 for example to atmosphere.

In use, the system 10 enables gas turbines and in particular the relatively advantageous micro turbines to be powered indirectly using solid fuels. Heretofore, driving gas turbines and in particular micro turbines has not been possible using solid fuel.

The advantage of being able to use solid fuel, is that sustainable and renewable source fuels can be used, as well as waste and by-products, such as wood, paper, animal products and the like. The internals of the combustion chamber may be modified according to the fuels to be combusted.

In use, suitable fuels are inputted into the combustion chamber 16 through the inlet 20, and these are ignited to combust.

Heat and gases generated by combustion rise up the chamber 16 and pass around the outside of the conduit 22 of the heat exchanger 18 through the space 33 therebetween. The baffles 29,31 help direct the combustion gases over the conduit 22. As this is happening, air is compressed by the compressor 28 and fed through the inlet 24 into the heat exchanger at a temperature of approximately 200°C. As the air passes through the passages 26a-l of the heat exchanger 18 toward the outlet 26, the combustion gases heat up the air, until it exits through the outlet 26 generally at a temperature in the order of 850°C. The ceramic lining on the housing 35 help to improve the efficiency of the exchanger.

This heated air is then introduced to the turbine 14, whereby the heated air, which is now relatively fast moving, turns blades within the turbine 14 thereby driving the turbine 14 to generate electricity through the generator 32, which electricity is subjected to an inverter/rectifier 14 for output for use, for example for powering electrical apparatus and systems in the normal way.

The heated air that drives the micro turbine 14 is vented off once past the blades and fed back into the combustion chamber 16 through the inlet 36. This air is at a temperature in the order of 550°C, and therefore when inputted into the chamber 16 acts to improve the efficiency of combustion, and also heating of further air as it passes through the exchanger 18.

As combustion continues, combustion gases which have been used to heat air, and therefore which are of relatively low temperature (in the order of 300°C), are vented through the outlet 28 to heat up an appliance 40, such as a radiator. This provides for further efficiency of the system.

It will be appreciated that the system 10 according to the present invention provides for the efficient generation of electrical power using sustainable and renewable sources of fuel to drive micro turbines, and therefore allows the advantages of micro turbines to be coupled with the advantages of using sustainable and renewable fuels.

The combustion of fuels produces combustion products such as soot and other carbonaceous materials which form deposits on the outside of the conduit 22. As these build up they could detrimentally affect heat exchange and so it is a feature of the exchanger 18 that it can be selectively dismantled to enable cleaning.

Various modifications may be made without departing from the spirit or scope of the present invention. For example, the arrangement and structure of a heat exchanger may be varied according to desired applications. Moreover, a plurality of heat exchangers may be used. The system may use any suitable fluid to be heated, such as a gas from a gas source.

The system may comprise any number of the aforesaid components and features in any combination.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims

1. A power generating system comprising a combustion arrangement in which combustion of fuel material is used to heat a fluid and a turbine which is driven by the heated fluid to generate power.

2. A power generating system according to claim 1, in which the turbine is a gas turbine.

3. A power generating system according to claim 1 or claim 2, in which the turbine comprises a micro turbine.

4. A power generating system according to any preceding claim, in which the combustion arrangement comprises a combustion chamber associated with which is a heat exchanger through which fluid passes to be heated.

5. A power generating system according to claim 4, in which the heat exchanger comprises a fluid inlet through which fluid is introduced into the heat exchanger.

6. A power generating system according to claim 5, in which fluid introduced in partially pre-heated.

7. A power generating system according to claim 5 or claim 6, in which fluid introduced into the heat exchanger is under compression.

8. A power generating system according to claim 6 or claim 7, in which the fluid has been passed through a compressor which has pre-heated the fluid.

9. A power generating system according to any of claims 4 to 8, in which fluid is introduced at a temperature in the range 150-250°C.

10. A power generating system according to claim 9, in which the fluid is introduced at a temperature of approximately 200°C.

11. A power generating system according to any of claims 4 to 10, in which the fluid is a gas.

12. A power generating system according to claim 11, in which the fluid is atmospheric air.

13. A power generating system according to any of claims 4 to 12, in which the heat exchanger is located in an upper part of the combustion chamber.

14. A power generating system according to any of claims 4 to 12, in which the heat exchanger is located at or near the top thereof.

15. A power generating system according to any of claims 4 to 14, in which the heat exchanger comprises a conduit through which fluid flows to be heated, the conduit defining a tortuous path to facilitate the heating of fluid therein.

16. A power generating system according to claim 15, in which the heat exchanger keeps the fluid separate from combustion gases generated during combustion, whilst allowing the gases to pass around the outside of the conduit whereby to heat the fluid passing through the conduit.

17. A power generating system according to claim 15 or claim 16, in which means is provided in the heat exchanger to divert combustion gases over the conduit to facilitate heat transfer.

18. A power generating system according to claim 17, in which the means is in the form of baffles.

19. A power generating system according to claim 17 or claim 18, in which the means is selectively removable.

20. A power generating system according to any of claims 4 to 19, in which the heat exchanger comprises insulation material to further improve heat transfer.

21. A power generating system according to claim 20, in which the insulation material lines the inside of a housing of the exchanger.

22. A power generating system according to claim 20 or claim 21, in which the material comprises ceramics material.

23. A power generating system according to any of claims 4 to 22, in which the heat exchanger comprises materials able to resist high temperatures and retain strength and geometry at temperatures up to in the order of 1000°C whilst providing good conduction of heat, such as exotic stainless steel or other suitable, conductive yet durable material.

24. A power generating system according to any of claims 4 to 23, in which the heat exchanger is readily dismantled, at least in part, to facilitate cleaning thereof, in particular cleaning of the outside of the conduit for example to remove combustion by-products such as soot and other carbonaceous deposits.

25. A power generating system according to any of claims 4 to 24, in which the heat exchanger is arranged to allow fluid passing therethrough to be heated to approximately 800-900°C, depending upon the material being combusted.

26. A power generating system according to any of claims 4 to 25, in which the combustion chamber is arranged to accommodate combustion of a range of fuel materials, in particular solid fuels such as combustible waste, fossil fuels and wood.

27. A power generating system according to claim 26, in which the chamber is arranged to accommodate combustion of sustainable and/or renewable fluid.

28. A power generating system according to any of claims 4 to 27, in which heated fluid exits the heat exchanger to be introduced to the turbine to drive the turbine to generate electrical power.

29. A power generating system according to any of claims 4 to 28, in which a

conduit connects the heat exchanger to the turbine.

30. A power generating system according to any of claims 4 to 29, in which the turbine is remote from the heat exchanger.

31. A power generating system according to any preceding claim, in which means is provided to process generated power.

32. A power generating system according to claim 31, in which the means comprises an inverter/rectifier means.

33. A power generating system according to any of claims 4 to 32, in which means is provided to feed heated fluid which has driven the turbine back into the combustion chamber where any residual heat in the fluid will facilitate and enhance the efficiency of combustion.

34. A power generating system according to any of claims 4 to 33, in which the system further comprises means to utilise waste gases from the combustion chamber, particularly to use the residual heat in the gases to heat for example an appliance, such as a radiator, before the gases are exhausted from the system.

35. A method of generating power, the method comprising combusting fuel in a combustion arrangement to heat fluid and using said heated fluid to drive a turbine to generate power.

36. A method according to claim 35, which comprises the use of a system as claimed in any of claims 1 to 34.

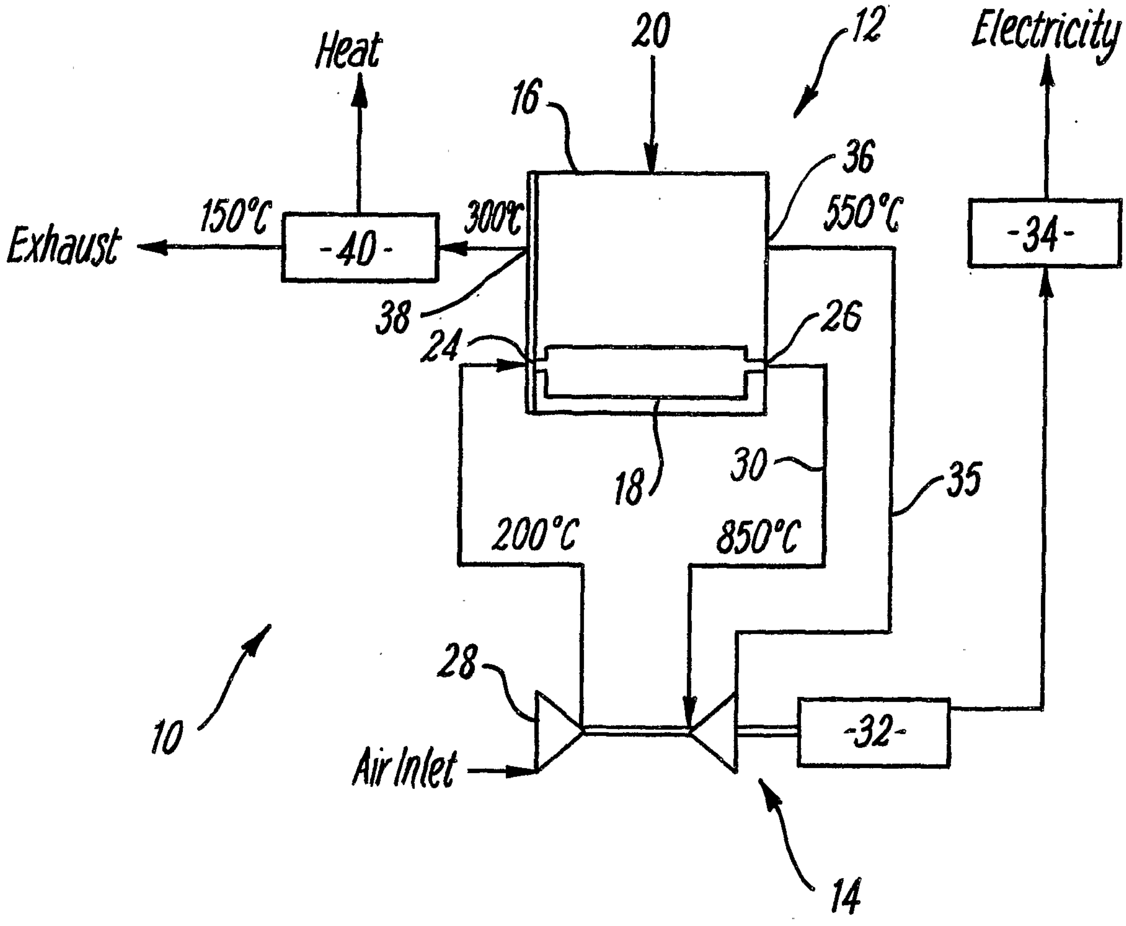
37. A combustion arrangement for use in a system according to any of claims 1 to 34.

38. A power generating system substantially as hereinbefore described with reference to the accompanying drawings.

39. A method substantially as hereinbefore described with reference to the accompanying drawings.

40. A combustion arrangement substantially as hereinbefore described with reference to the accompanying drawings.

41. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.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Exhaust
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35
200°C
850°C
28
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Air Inlet
-32-
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FIG. 1

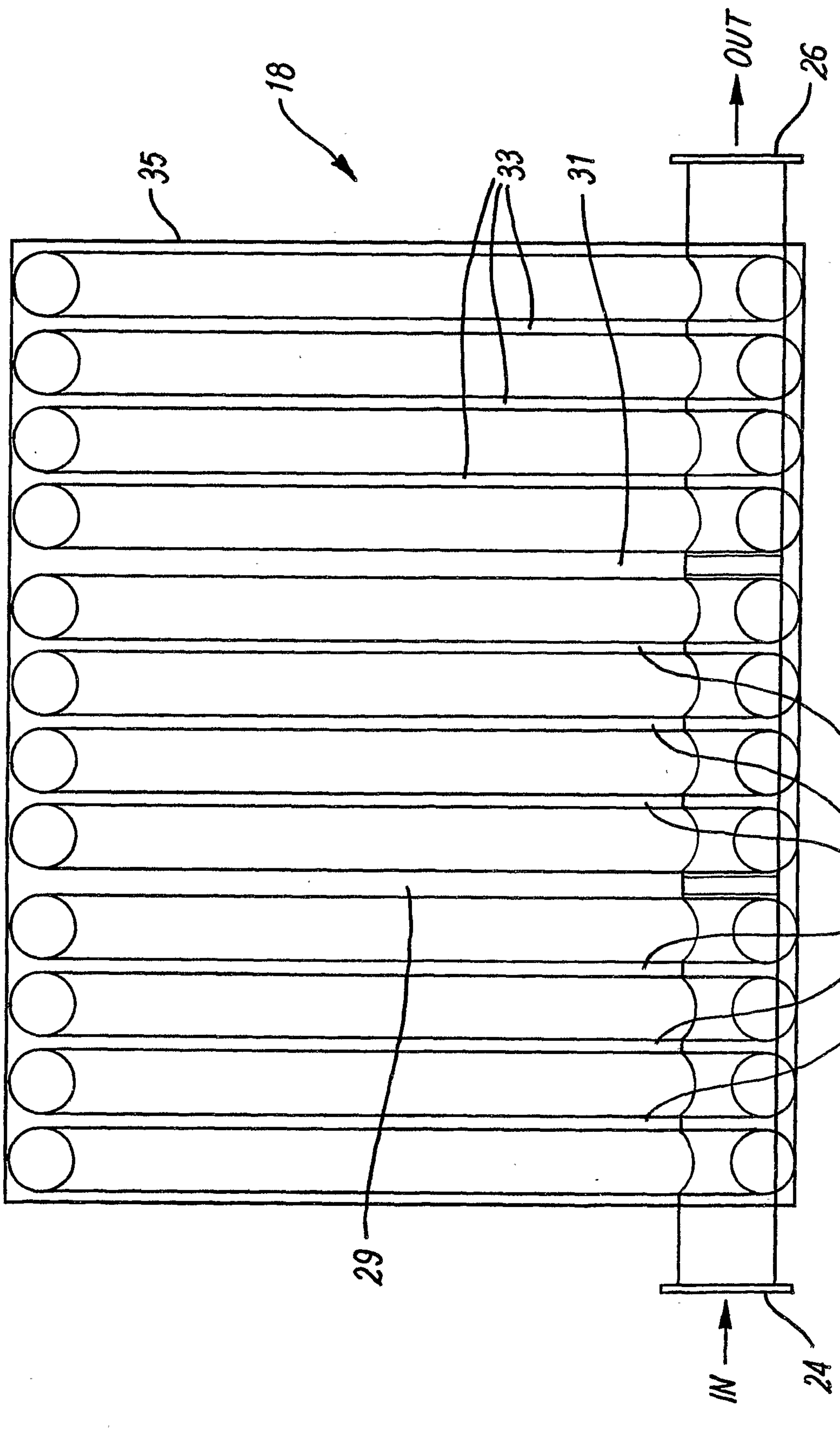

FIG. 2

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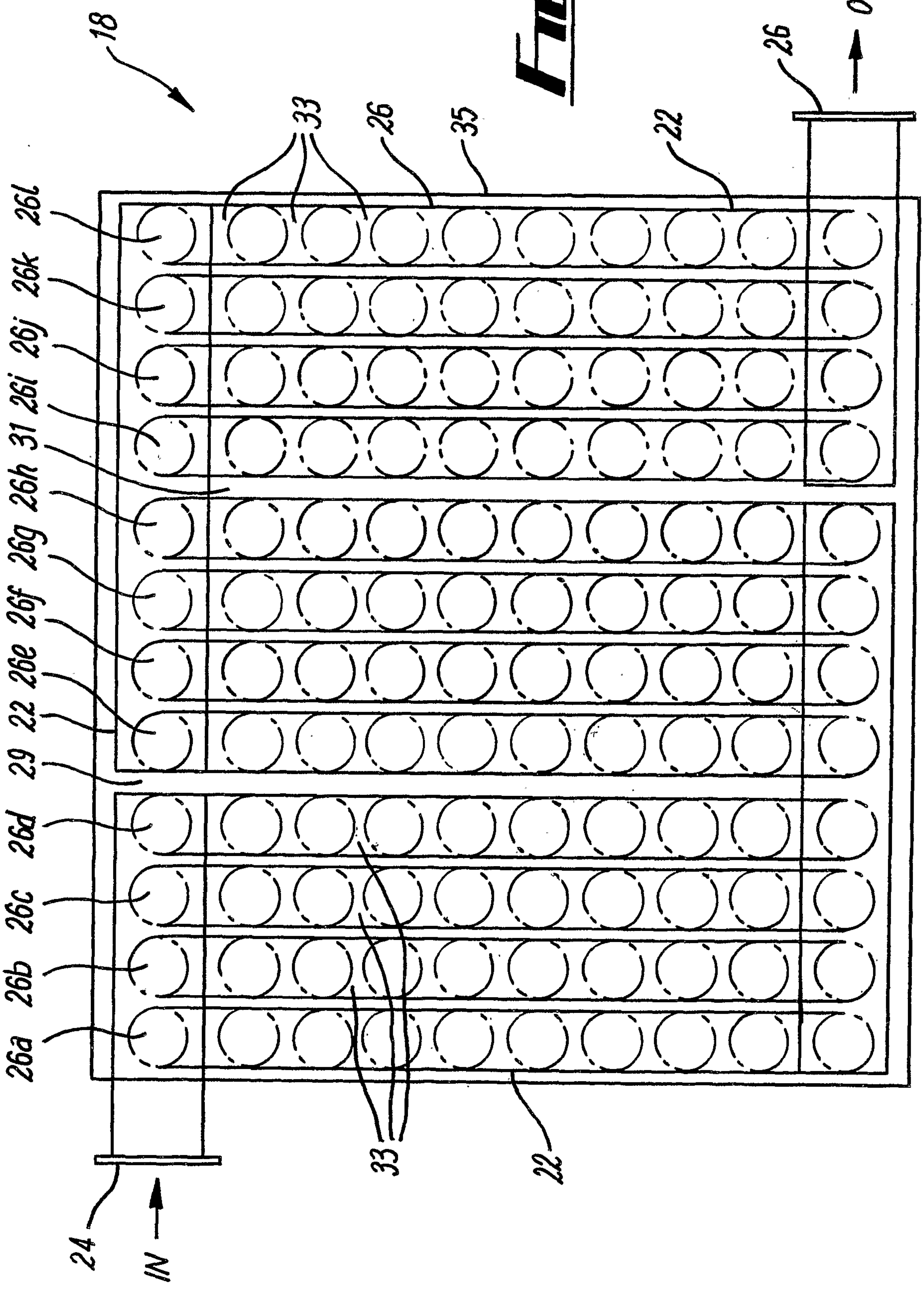
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FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/05500

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F02C1/04 F02C3/26 F02C6/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 687 570 A (BRONICKI LUCIEN Y ET AL) 18 November 1997 (1997-11-18)	1-17,23, 25-31, 33-41
Y		18,19,24
Y		22
Y		32
	column 1, line 14 - line 37 column 3, line 41 - line 58 column 8, line 66 -column 9, line 15 figure 7 ---	
Y	US 5 775 267 A (HOU LIANG-YU ET AL) 7 July 1998 (1998-07-07) column 2, line 59 - line 67 column 6, line 33 - line 41; figures ---	18,19,24
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2002	24/04/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Criado Jimenez, F

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 642 864 A (METCALFE ARTHUR G ET AL) 17 February 1987 (1987-02-17) abstract column 2, line 28 - line 44	22
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INTERNATIONAL SEARCH REPORT

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